

**NATIONAL POLAR-ORBITING
OPERATIONAL ENVIRONMENTAL
SATELLITE SYSTEM (NPOESS)
PREPARATORY PROJECT (NPP)**

**PERFORMANCE VERIFICATION PLAN
(PVP)**

April 12, 2000



**GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND**

**INTEGRATED PROGRAM OFFICE
SILVER SPRING, MARYLAND**

NPP Performance Verification Plan (PVP)

April 12, 2000

Goddard Space Flight Center
Greenbelt, Maryland

Integrated Program Office
Silver Spring, Maryland

NPP Performance Verification Plan (PVP)

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Table of Contents

<u>Section</u>	<u>Page</u>
1.0 INTRODUCTION	1-1
1.1 PURPOSE	1-1
1.2 SCOPE	1-1
1.3 NPP Overview	1-1
1.3.1 Space Segment	1-2
1.3.2 Command, Control and Communications Segment	1-2
1.3.3 Interface Data Processing Segment	1-3
1.3.4 Science Data Segment	1-3
1.3.5 Archive and Distribution Segment	1-4
1.3.6 Launch Service Segment	1-4
1.4 Related Documents	1-4
2.0 VERIFICATION PROCESS	2-1
2.1 DEFINITIONS	2-1
2.2 VERIFICATION APPROACH	2-1
2.3 Verification Activities	2-2
2.3.1 Element Verification	2-4
2.3.2 Segment Verification	2-4
2.3.3 Ground/Space System Verification	2-6
2.3.4 Mission System Verification	2-6
2.3.5 On-Orbit Verification	2-6
3.0 VERIFICATION MANAGEMENT	3-1
3.1 VERIFICATION ROLES AND RESPONSIBILITIES	3-1
Appendix A Acronyms	A-1

Figures

<u>Figure</u>	<u>Page</u>
Figure 1.3-1 NPP System Overview	1-2
Figure 2.2-1 NPP Verification Approach	2-2
Figure 2.3-1 NPP Verification Activities	2-3

Tables

<u>Table</u>	<u>Page</u>
Table 2.3-1 Element Verification Activities	2-4
Table 2.3-2 Segment Verification Activities	2-5
Table 3.1-1 Verification Roles and Responsibilities	3-1

1.0 INTRODUCTION

1.1 PURPOSE

The National Polar Orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) Performance Verification Plan (PVP) documents the activities National Aeronautics and Space Administration (NASA) and NPOESS Integrated Program Office (IPO) plan to execute for the integration and verification of the NPP mission.

This plan defines the hierarchy of the integration and verification process. This includes:

- Segment / element / component verification activities
- Inter segment verification activities
- Mission system (ground and flight systems) verification
- Post launch verification.

1.2 SCOPE

The PVP defines the overall philosophy for the NPP system verification, including development, pre-launch integration testing and on-orbit verification.

1.3 NPP OVERVIEW

The NPP is a joint partnership between NASA and the NPOESS IPO whose mission is to accomplish the following objectives:

- Demonstrate and validate global environmental imaging and sounding instruments, algorithms and pre-operational ground systems in order to provide risk reduction to the first NPOESS flight.
- Provide continuity of the calibrated, validated and geo-located EOS Terra and Aqua systematic global imaging and sounding observations for NASA Earth Science research.

For mission definition and formulation purposes, the NPP system is defined at the highest level in terms of six segments, see Figure 1.3-1, NPP System Overview. The six segments are used for the purpose of describing the System with the understanding that some functions currently found within one segment may ultimately be implemented in another segment, should it be deemed appropriate.

coordinating the joint program operations needs. Mission Management represents both the operational and scientific communities.

The satellite operations capabilities include the mission planning and scheduling, resource coordination, building, verifying and sending of command loads, and maintenance of spacecraft databases. Off-line activities include spacecraft simulation, flight software maintenance, mission trending and analysis, and as necessary anomaly resolution. The communication routing functions include those activities associated with the planning, scheduling and coordination of network communication links. The polar ground station coordination and intra-segment communication services are also provided.

1.3.3 Interface Data Processing Segment

The Interface Data Processing Segment (IDPS) provides for ingest of raw sensor telemetry received from the polar ground stations. The artifacts from the communication routing are removed, providing raw data records (RDRs), which are subsequently processed to create Sensor Data Records (SDRs) and Environmental Data Records (EDRs). The RDRs, SDRs, and EDRs are made available to five meteorological Centrals for use in application specific weather related predictions. The five Centrals are:

- National Environmental Satellite, Data, and Information Service (NESDIS)
- Air Force Weather Agency,
- 55th Space Weather Squadron,
- Fleet Numerical Meteorology and Oceanography Center (FNMOC), and
- Naval Oceanographic Office (NAVOCEANO).

The data records are provided to the Centrals on a time critical basis (three hours from sensor acquisition), although as a pre-operational demonstration, this timeliness is viewed as a goal rather than an operational requirement. Additionally, the IDPS also provides an operational level of calibration and validation of the algorithms and the performance of the payload sensors. The RDRs, SDRs, and EDRs are forwarded to the Archive and Distribution Segment (ADS) for archiving and broader user access.

1.3.4 Science Data Segment

The Science Data Segment (SDS) ingests the RDRs from the IDPS. The SDS validates format and volume/size of the RDRs, ensuring all data are received. The SDS processes the RDRs, creating a Level 1B product. The Level 1B is comparable to the IDPS SDR product, but will be generated using more robust, science quality algorithms. The RDRs are stored for the life of the mission, permitting reprocessing when improved science algorithms are made available from the science community.

The Level 1B data are provided to a small, competitively selected science user group who are responsible for generating identified Level 2/3 science products. These products are unique to the science research community or represent a significant science improvement beyond the IDPS EDRs. To the extent feasible, the EDRs are

planned to serve the global change community, in addition to the operational weather community, minimizing the extent and scope of the SDS. It is intended that the SDS algorithms may be coordinated with the Centrals and ultimately be incorporated as part of their nominal routine processing. The SDS also performs science calibration and validation and coordinates with the IDPS on results, and as necessary calibration file changes. All Level 1B and Level 2/3 products are provided to the ADS providing wide user access to all science products.

1.3.5 Archive and Distribution Segment

The Archive and Distribution Segment (ADS) receives the RDRs, SDRs, and EDRs from the IDPS and the Level 1B and Level 2/3 products from the SDS. All of these data are archived, as are the associated metadata, upon which users may search and order data. Upon request, data products are distributed to users who are billed for the cost of fulfilling the request.

1.3.6 Launch Service Segment

The Launch Service Segment (LSS) provides those assets and services associated with the launch vehicle (LV) and the payload integration. Included along with the launch vehicle, are all ground support equipment, property, and facilities to integrate the spacecraft to the LV, verify their integration, and conduct pre-launch testing with the remainder of the ground system.

1.4 RELATED DOCUMENTS

- a. Initial Implementation Agreement (IIA) between National Aeronautics and Space Administration (NASA) and National Polar - Orbiting Operational Environmental Satellite System (NPOESS) Integrated Program Office (IPO) for the NPOESS Preparatory Project (NPP), 27 November 1999.
- b. NPP Program Requirements
- c. NPP Mission System and Operations GSFC 429-99-02-02 (Draft 2,12/3/1999)
- d. NPP Level 2 Requirements (TBD)

2.0 VERIFICATION PROCESS

2.1 DEFINITIONS

The following definitions are established to provide a common reference.

System – a grouping of two or more NPP segments

Segment – one of the following NPP Formulation Phase elements: Space, C3, IDPS, SDS, ADS, and LSS

Element – a grouping of one or more components that when logically grouped comprise a segment

Component – a single piece of hardware or software when logically grouped comprise an element

Integration – an activity combining functional or physical elements with segments, or a segment with another segment

Verification – the contractual or programmatic process used to assess the requirements of the NPP system and its segments

Analysis – a verification method, which utilizes proven analytical techniques and/or tools to assess requirements implementation, manufacturing processes, test results and other aspects of verification where flight or actual operation conditions cannot be simulated adequately

Inspection – a verification method used to verify design requirements of physical characteristics such as construction features, visible workmanship, labels, interface dimension, etc.

Demonstration – a verification method using a qualitative method to assess requirements that evaluates the properties of the item by observation

Test – a verification method to assess functional or performance requirements by measuring output responses to known stimuli

Engineering test – an activity to exercise a particular capability or function without the formality of verification processes. Also known as informal or development testing.

2.2 VERIFICATION APPROACH

NPP verification activities are conducted across all development and integration phases of the NPP system. The ultimate objective is to verify and measure the extent to which the system can reliably support end-to-end system functionality and operations. As shown in Figure 2.2-1, NPP verification is accomplished through an integrated

hierarchical approach comprised of a series of verification activities. During the pre-launch phase, individual system components are verified, followed by a progression of verification activities at the element, segment level and complete with the verification of the mission as a whole. Verification continues into the post-launch phase and focuses on real-time NPP system performance verification.

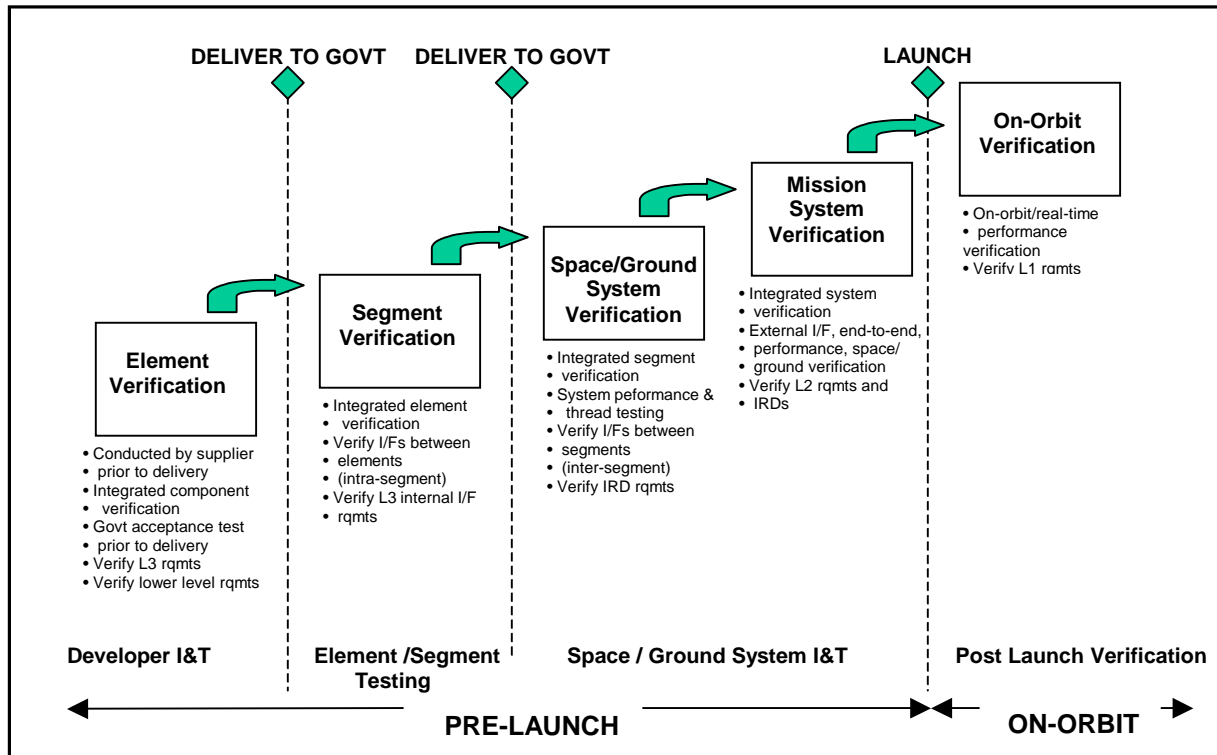


Figure 2.2-1: NPP Verification Approach

2.3 VERIFICATION ACTIVITIES

The elements, segments, and systems comprising the NPP are verified utilizing the approach described above. Figure 2.3-1 shows the various NPP verification activities, key input and output products, and organizations having lead responsibility for conducting the verification. Results of each verification activity are documented in reports describing the verification processes performed, results, anomalies, and risks. Verification results and findings are incorporated into subsequent verification activities.

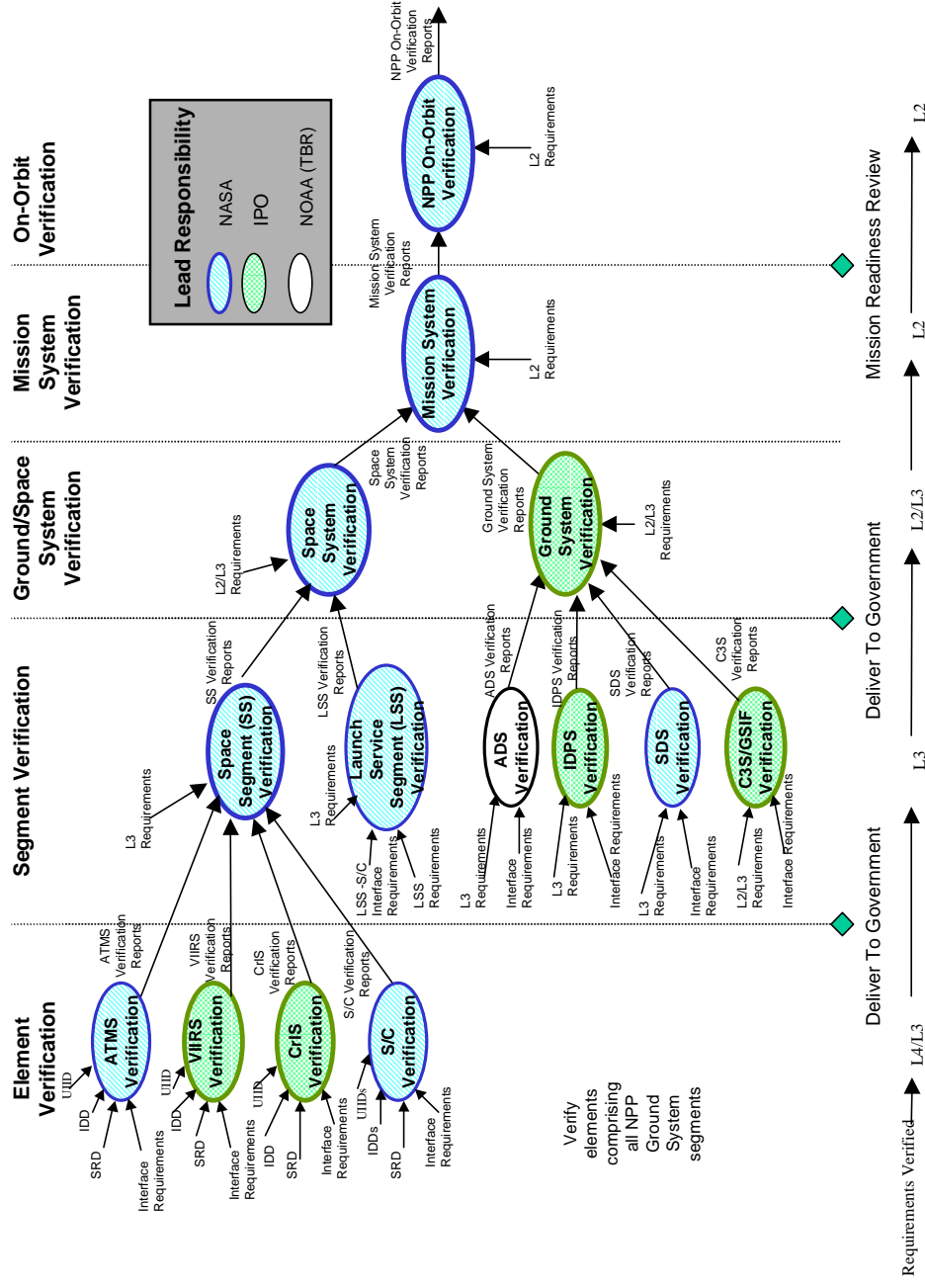


Figure 2.3-1: NPP Verification Activities

2.3.1 Element Verification

Element verification is performed by the Developers prior to their delivery to the Government. Element verification entails the integration of lower-level components that are verified prior to the elements, as part of the Developers' internal activities. Element verification focuses on Level 3 requirements and is performed by the recipient government organization or their designated developer(s) as applicable. Specific element verification activities for NPP are shown in Table 2.3-1 below.

Element	Verification Activities / Details
ATMS Instrument Element [NASA]	Developer Performs: <ul style="list-style-type: none"> • Stand-alone ATMS verification (analysis, testing, etc.) • Preliminary engineering tests to verify ATMS interfaces with Spacecraft
VIIRS Instrument Element [IPO]	Developer Performs: <ul style="list-style-type: none"> • Stand-alone VIIRS verification (analysis, testing, etc.) • Preliminary engineering tests to verify VIIRS interfaces with Spacecraft
CrIS Instrument Element [IPO]	Developer Performs: <ul style="list-style-type: none"> • Stand-alone CrIS verification (analysis, testing, etc.) • Preliminary engineering tests to verify CrIS interfaces with Spacecraft
Spacecraft (SC) Element [NASA]	Developer Performs: <ul style="list-style-type: none"> • Stand-alone SC verification (analysis, testing, etc.) • Preliminary engineering tests to verify SC interfaces with science instruments • Development testing with instruments • Development testing with C3S

Table 2.3-1 Element Verification Activities

2.3.2 Segment Verification

Verified elements are integrated into segments and verification is subsequently performed at the segment level. Segment verification focuses on intra-segment interfaces defined by Level 3 internal interface requirements and is performed by the organization(s) having responsibility for the elements that comprise the segment. Specific segment verification activities for NPP are shown in Table 2.3-2 below.

Segment	Verification Activities / Details
Space Segment (SS)	<ul style="list-style-type: none"> • Verify external interfaces of the Space segment • Integration and test of ATMS, VIIRS, CrIS with spacecraft • Development testing with C3S
Launch Services Segment (LSS)	<p>Developers Perform:</p> <ul style="list-style-type: none"> • Stand-alone LSS verification (analysis, testing, etc.) • Verify launch support aerospace ground equipment (AGE) • Verify payload processing facilities • Verify Air Force Western Range support products and services • Verify LSS internal interfaces • Development testing with C3S
Command, Control, and Communications Segment (C3S)	<p>Developers Perform:</p> <ul style="list-style-type: none"> • Stand-alone C3S verification (analysis, testing, etc.) • Verification of mission management activities satellite operations, and the space/ground communications • Preliminary engineering tests to verify interfaces between C3S elements • Verify C3S/GSIF interfaces and Integrate • Development testing with SS • Development testing with LSS • Development testing with IDPS
Interface Data Processing Segment (IDPS)	<p>Developers Perform:</p> <ul style="list-style-type: none"> • Stand-alone IDPS verification (analysis, testing, etc.) • Verify the IDPS system management and administration, data ingest, storage management, data records processing, and data formatting and distribution • Verify IDPS internal interfaces • Development testing with C3S • Development testing with SDS • Development testing with ADS
Science Data Segment (SDS)	<p>Developers Perform:</p> <ul style="list-style-type: none"> • Stand-alone SDS element verification (analysis, testing, etc.) • Verify ingest of RDR, calibration data, • Verify the SDS resource management and monitor Level 1B product generation • Verify higher level product generation • Verify mission storage management, data formatting and distribution to science users • Verify SDS internal interfaces • Development testing with IDPS • Development testing with ADS
Archive and Distribution Segment (ADS)	<p>Developers Perform:</p> <ul style="list-style-type: none"> • Stand-alone ADS verification (analysis, testing, etc.) • Verify the ADS data ingest, archive management • Verify user request services, order processing, product shipment, order accounting, and report generation • Verify ADS internal interfaces • Development testing with IDPS • Development testing with SDS

Table 2.3-2 Segment Verification Activities.

2.3.3 Ground/Space System Verification

Ground/Space System verification is performed upon completion of segment verification activities. Verified segments are integrated and inter-segment interfaces, defined by IRD specifications, verified. System performance and thread testing is conducted to verify system functionality and performance. System verification is performed by the organization(s) having responsibility for the segments that comprise the system. Specific system verification activities for NPP include:

- Verify Ground System [NASA, IPO]
 - Integrate C3S, IDPS, SDS, and ADS segments and verify the functionality and interfaces between them
 - Interconnecting network performance
 - Ground system end-to-end performance
- Verify Space Segment and Launch Services Segment Interfaces [NASA]
 - Integrate the Space Segment and the LSS and verify the functionality and interfaces between them
- Verify External Interfaces (TBD)

2.3.4 Mission System Verification

NPP mission verification is accomplished by integrating the Space Segment, the Launch Services Segment, and the Ground System to ensure mission space-to-ground requirements are met and the system is ready for launch. Mission verification entails end-to-end verification and focuses on Level 2 requirements. It includes the following activities:

- Verify Space System and Ground System Interfaces [NASA, IPO]
 - Telemetry processing between primary ground and space systems
 - Command processing between primary ground and space systems
 - Interconnecting network(s)
- Verification of end-to-end Space System/Ground System
 - End-to-end telemetry processing
 - End-to-end command processing
 - End-to-end science data processing/distribution
 - Interconnecting network(s) for planning, management, etc.

2.3.5 On-Orbit Verification

NPP on-orbit verification is performed once the spacecraft is launched and in orbit. Activities focus on verifying real-time operational performance with respect to Level I/II requirements. Verification activities during on-orbit operations are generally based upon the NPP System Concept of Operations document.

3.0 VERIFICATION MANAGEMENT

3.1 VERIFICATION ROLES AND RESPONSIBILITIES

This section describes the roles and responsibilities of NASA IPO and NOAA (TBR) for the verification activities.

Verification Activity	Lead Role		
	IPO	NASA	NOAA (TBR)
On-Orbit Verification		X	
Mission System Verification		X	
Ground/ Flight System Verification			
Ground System		X	
Flight System		X	
Segment Verification			
Space Segment		X	
LSS		X	
C3S	X		
SDS		X	
IDPS	X		
ADS			X
Element Verification			
Spacecraft		X	
CrIS	X		
VIIRS	X		
ATMS		X	
Interfaces Verification (Internal)	TBD		
ATMS to S/C Interfaces			
CrIS to S/C Interfaces			
LSS to C3S Interfaces (TBD)			
C3S to IDPS Interfaces			
SDS to ADS Interfaces			
SDS to IDPS interfaces			
IDPS to ADS Interfaces			
VIIRS to S/C Interfaces			
Space Segment to C3S Interfaces			
Interfaces Verification (External)	TBD		
From NPP Mission System			
To GPS			
To Ancillary Data Systems			
To AFSCN Networks			
To Space Network			
To EUMETSAT			
To Ka Ground Terminal			
To Application Processing Systems			
To Direct Broadcast Receive Systems			

Appendix A

Acronyms

ADS	Archive and Distribution Segment
AGE	Aerospace Ground Equipment (Launch support)
ATMS	Advanced Technology Microwave Sounder
C3S	Command, Control and Communications Segment
CONOPS	System and Operations Concept
CrIS	Cross-Track Infrared Sounder
EDR	Environmental Data Record
EUMETSAT	European Meteorological Satellite organization
FNMOCC	Fleet Numerical Meteorology and Oceanography Center
GPS	Global Positioning System
GSIF	Ground Station Interface Facility
IDD	Instrument Description Document
IDPS	Interface Data Processing Segment
IIA	Interim Interagency Agreement
IOO	Instrument Of Opportunity
IPO	Integrated Project Office (NPOESS)
IRD	Interface Requirements Document
LSS	Launch Service Segment
LV	Launch Vehicle
NAVOCEANO	Naval Oceanographic Office
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
PVP	Performance Verification Plan
RDR	Raw Data Record
SDR	Sensor Data Records
SDS	Science Data Segment
SRD	Sensor Requirements Document
SS	Space System
UIID	Unique Instrument Interface Document
VIIRS	Visible-Infrared Imager Radiometer